Art. 100 – Definitions

Overcurrent Protective Device, Branch-Circuit:
A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating.

Branch-circuit overcurrent protective devices are provided with interrupting ratings appropriate for the intended use but no less than 5,000 amperes.

Interrupting Rating:
The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

IN: Equipment that is intended to interrupt current at other than faults levels may have the rating implied; such as horsepower of locked current ratings.
If possible:
Show video of effects of non-current limiting and current limiting fuses on loose wire
Show video of misapplied IC rating

Art. 100 – Definitions

Circuit Breaker:
A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. (won’t be destroyed)

Circuit Breaker - Adjustable (as applied to CB): A qualifying term indicating that the circuit breaker can be set to trip at various values of current, time, or both, within a predetermined range.

Instantaneous Trip (as applied to CB): A qualifying term indicating that no delay is purposely introduced in the tripping action of the circuit breaker.

Art. 100 – Definitions

Inverse Time (as applied to circuit breakers): A qualifying term indicating that there is purposely introduced a delay in the tripping action of the circuit breaker, which delay decreases as the magnitude of the current increases. Higher current = shorter time to trip

Nonadjustable (as applied to circuit breakers): A qualifying term indicating that the circuit breaker does not have any adjustment to alter the value of current at which it will trip or the time required for its operation.

Setting (of circuit breakers): The value of current, time, or both, at which an adjustable circuit breaker is set to trip. Actual value of time and current to trip

Art. 100 – Definitions

Coordination (Selective):
Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings.

These apply to the full range of overcurrents from overload to full fault current, and the full range of opening times.

Selective Coordination

90-Amp Breaker downstream from a 400-Amp Breaker
- Point A – 90A starts to open
- Point B – 400A starts to open
- Point C – 90A breaks the circuit
- Point D – 400A breaks the circuit
Series Protection

Ground-Fault Protection of Equipment (GFPE):
A system intended to provide protection (to) of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit.
This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device.
(Protects the equipment but not necessarily people)

Insulated Cable Engineers Association – Table

ICEA Table

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<th>Copper Wire Size 75°C Thermoplastic</th>
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*Extrapolated data

Art. 100 – Definitions

Overcurrent Protective Device, Supplementary:
A device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaires and appliances.
This limited protection is in addition to the protection provided in the required branch circuit by the branch circuit overcurrent protective device.
(Not a substitution for branch circuit protection)
**Over 1000 Volts, Nominal**

**Electronically Actuated Fuse:**

An overcurrent protective device that generally consists of a control module that provides current sensing, electronically derived time-current characteristics, energy to initiate tripping, and an interrupting module that interrupts current when an overcurrent occurs.

Electronically actuated fuses may, or may not, operate in a current-limiting fashion, depending on the type of control selected.

**Art. 240 Part IX Over 1000 Volts, Nominal**

**Non-vented Power Fuse:**

A fuse without intentional provision for the escape of arc gases, liquids, or solid particles to the atmosphere during circuit interruption.

**Vented Power Fuse:**

A fuse with provision for the escape of arc gases, liquids, or solid particles to the surrounding atmosphere during circuit interruption.

**Over 1000 Volts, Nominal**

**Fuse:** An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

**Controlled Vented Power Fuse:** A fuse with provision for controlling discharge circuit interruption such that no solid material may be exhausted into the surrounding atmosphere.

**Expulsion Fuse Unit (Expulsion Fuse):** A vented fuse unit in which the expulsion effect of gases produced by the arc and lining of the fuseholder, either alone or aided by a spring, extinguishes the arc.

**Power Fuse Unit:**

A vented, non-vented, or controlled vented fuse unit in which the arc is extinguished by being drawn through solid material, granular material, or liquid, either alone or aided by a spring.

**Over 1000 Volts, Nominal**

**Multiple Fuse:**

An assembly of two or more single-pole fuses.

**Wiring & Overcurrent Protection and the NEC®**
**210.4 Multiwire Branch circuit**

(A) General. A multiwire circuit shall be permitted to be considered as multiple circuits. All conductors of a multiwire branch circuit shall originate from the same panelboard or similar distribution equipment.

(B) Disconnecting Means. Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates.

**210.4**

(D) Grouping. The ungrounded and grounded circuit conductors of each multiwire branch circuit shall be grouped as per Art 200.4 (by cable ties or similar means in at least one location within an enclosure)

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious or if the conductors pass through a box or conduit body without a loop, or without a splice or termination.

**240.2 Definitions**

**Supervised Industrial Installation.** For the purposes of Part VIII, the industrial portions of a facility where all of the following conditions are met:

(1) Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system.

(2) The premises wiring system has 3500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220.

(3) The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase.

This definition excludes installations in buildings used by the industrial facility for offices, warehouses, garages, machine shops, and recreational facilities that are not an integral part of the industrial plant, substation, or control center.

**240.4 (B) Overcurrent Devices Rated 800 Amps or Less (generally)**

The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted, provided all of the following conditions are met:

(1) (f) The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads. (Multi-receptacle branch circuits are not eligible for up sized OC protection)

AND

(2) (f) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or circuit breaker without overload trip adjustments above its rating. See Table 240.6 (but that shall be permitted to have other trip or rating adjustments). (lower trip adjustments)

AND

(3) The next higher standard rating selected does not exceed 800 amperes.
240.4(C) Overcurrent Devices Rated over 800 Amperes.
Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device defined in 240.6.
(conductor-rated ampacity must meet or exceed the OC protection rating)

240.4(D) Small Conductors

(1) 18 AWG (7 amperes with restrictions)
(2) 16 AWG (10 amperes with restrictions)
(3) 14 AWG Copper (15 amperes)
(4) 12 AWG Aluminum and Copper-Clad Aluminum (15 amperes)
(5) 12 AWG Copper (20 amperes)
(6) 10 AWG Aluminum and Copper-Clad Aluminum (25 amperes)
(7) 10 AWG Copper (30 amperes)

240.5 Protection of Flexible Cords and Cables, and Fixture Wires

These wires shall be protected from overcurrent as in Art. 400.5(A) or (B)
(A) Ampacities for flexible cords and cables as per Table 400.4 (1) and (A)(2)
      Ampacities for fixture wire as per Table 402.5
      Supplemental protection as per 240.10
(B) Branch circuit overcurrent device - shall protect the branch circuit as in (B)(1-4) below.
      1. Listed appliance or luminaire – use approved supply wires
      2. Fixture wire: 20A – #18 for 50 ft; #16 for 100 ft, etc.
      3. Extension cords – as listed
      4. Field assembled extension cords: 20A – #16 or larger

240.6 Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers

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240.6 Standard Ampere Ratings

(B) Adjustable-Trip Circuit Breakers.
The rating of adjustable trip circuit breakers having external means for adjusting the current setting (long-time pickup setting), not meeting the requirements of 240.6(C), shall be the maximum setting possible.
240.8 Fuses or Circuit Breakers in Parallel

Fuses and circuit breakers shall be permitted to be connected in parallel where they are factory assembled in parallel and listed as a unit.

Individual fuses, circuit breakers, or combinations thereof shall not otherwise be connected in parallel.

240.9 Thermal Devices

Thermal relays and other devices not designed to open short circuits or ground faults shall not be used for the protection of conductors against overcurrent due to short circuits or ground faults, but the use of such devices shall be permitted to protect motor branch-circuit conductors from overload if protected in accordance with 430.40.

(motor overload relays)

240.10 Supplementary Overcurrent Protection

Where supplementary overcurrent protection is used for luminaires, appliances, and other equipment or for internal circuits and components of equipment, it shall not be used as a substitute for required branch-circuit overcurrent devices or in place of the required branch-circuit protection.

Supplementary overcurrent devices shall not be required to be readily accessible.

240.12 Electrical System Coordination

Where an orderly shutdown is required to minimize the hazard(s), a system of coordination based on the following two conditions shall be permitted:

1. Coordinated short-circuit protection
2. Overload indication based on monitoring systems or devices

240.13 Ground-Fault Protection of Equipment

Ground-fault protection of equipment (GFPE) shall be provided for solidly grounded wye systems of more than 150 V to ground but not exceeding 1000 V phase-to-phase for each device used as a building disconnecting means rated 1000 amps or more.

This section shall not apply to the disconnecting means for:

1. Continuous industrial processes where a non-orderly shutdown will introduce additional hazards
2. Installations where GFPE is provided by other requirements for services or feeders
3. Fire pumps
240.15 Ungrounded Conductors

(A) Overcurrent Device Required.
A fuse or an overcurrent trip unit of a circuit breaker shall be connected in series with each ungrounded conductor.
You may use a CT and an overcurrent trip relay in lieu of a fuse.

(B) Circuit Breaker as Overcurrent Device.
Circuit breakers shall open all ungrounded conductors of the circuit both manually and automatically. (See 1-4 following)

240.15(B) Circuit Breaker as Overcurrent Device

(1) Multiwire Branch Circuit.
Individual single-pole circuit breakers, with identified handle ties, shall be permitted as the protection for each ungrounded conductor of multiwire branch circuits that serve only single-phase line-to-neutral loads. (Typically 120V loads)

(2) Grounded Single-Phase AC Circuits.
In grounded systems, individual single-pole circuit breakers rated 120/240 AC with identified handle ties shall be permitted as the protection for each ungrounded conductor for line-to-line connected loads for single-phase circuits. (Typically 240V loads)

240.15 Ungrounded Conductors

(3) 3-Phase and 2-Phase Systems:
In 4-wire, 3-phase, and 5-wire, 2-phase systems, individual breakers rated 120/240 with identified handle ties are permitted if the systems have a grounded neutral point and the voltage to ground does not exceed 120V. (Typically 120/208 V wye systems)

(4) 3-Wire DC Circuits:
Individual circuit breakers rated 125/250VDC with identified handle ties are permitted for 3-wire circuits to protect the line to line connected loads if there is a grounded neutral and the voltage to ground does not exceed 125V

Part II — 240.21 Location in Circuit

Overcurrent protection shall be provided in each ungrounded circuit conductor and shall be located at the point where the conductors receive their supply conductors receive their supply except as specified in 240.21(A)–(H).

Conductors supplied under the provisions of 240.21(A)–(H) shall not supply another conductor except through an overcurrent protective device meeting the requirements of 240.4. (Subsequent conductors protected by OC protection)
Part II — 240.21(A) Location of OC Protection

Branch-Circuit Conductors.
Branch-circuit tap conductors meeting the requirements specified in 210.19 (not less than maximum load after adjustment and correction factors are applied) shall be permitted to have overcurrent protection as specified in 210.20. (125% for continuous loads)

240.21(B) Feeder Taps

Conductors are permitted to be tapped without O.C. protection at the tap if to a feeder as specified in (B)(1)—(B)(5). The tap shall be permitted at any point on the load side of the feeder OCP device.

240.4(B) shall not be permitted.

(O.C. – next higher size - not over 800 A) rule are not permitted for tap conductors

(B)(1) Taps Not over 10 ft Long

(1) Where the length of the tap conductors does not exceed 10 ft and the tap conductors comply with all of the following:

(1) The ampacity of the tap conductors is:
   a. Not less than the combined calculated loads on the circuits supplied by the tap conductors, and
   b. Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors, or
   not less than the rating of the overcurrent protective device at the termination of the tap conductors.

10-foot Tap Rule

(1) Taps Not Over 10 feet Long

(2) The tap conductors do not extend beyond the switchboard, panelboard, disconnecting means, or control devices they supply.

(3) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which shall extend from the tap to the enclosure of an enclosed switchboard, panelboard, or control devices, or to the back of an open switchboard.

(4) For field installations if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less the 1/10 the rating of the OC device protecting the feeder.

25-foot Tap Rule

(B)(2) Taps Not over 25 feet Long

Where the length of the tap conductors does not exceed (25 ft) and the tap conductors comply with all the following:

(1) The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.

(2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.

(3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
240.21(B) 25’ Tap Rule

Taps that supply a transformer where the primary plus the secondary are not over 25 ft. All of the conditions of 1-5 are met:
1. The tap for the primary is at least 1/3 the ampacity of the feeder conductors
2. The secondary conductor ampacity is at least 1/3 of the feeder OC after the transformer ratio is used.
3. The primary plus the secondary conductors are not over 25 feet in length
4. Conductors are physically protected
5. The secondary terminates in OC protection

Transformer Pri + Sec: Not over 25 Feet

240.21(B)(3) Taps Supplying a Transformer Pri + Sec Not Over 25 Feet Long

240.21(B)(4) Taps Over 25 Feet Long

240.21(C) Transformer Secondary Conductors

A set of conductors feeding a single load, or each set of conductors feeding separate loads, shall be permitted to be connected to a transformer secondary, without overcurrent protection at the secondary, (in the transformer) as specified in 240.21(C)(1)–(C)(6).

The provisions of 240.4(B) shall not be permitted for transformer secondary conductors. (Cannot go to the next larger size of OC above the conductor ampacity)

Informational Note:
For overcurrent protection requirements for transformers, see 450.3.

C(1) Primary Overcurrent Only

240.21(C) Transformer Secondary 1-6
240.21(C)(1) Transformer Secondary Conductors

(1) Protection by Primary Overcurrent Device.
Conductors supplied by the secondary side of a single-phase transformer having a 2-wire secondary, or a three-phase, delta-delta connected transformer having a 3-wire secondary, shall be permitted to be protected by OCP provided on the primary side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.
E.g., 2:1 step down after – E.g., 30A sec. cond. x (1 src. voltage : pri. voltage) (1/2) = 15A Primary Fuse
Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors are not considered to be protected by the primary overcurrent protective device. Only these two configurations are protected by primary only protection.

240.21(C)(2) Transformer Secondary Conductors not over 10 Feet Long

Where the length of secondary conductor does not exceed 10 ft and complies with all of the following:

(1) The ampacity of the secondary conductors is:
   a. Not less than the combined calculated loads on the circuits supplied by the secondary conductors,
      AND
   b. Not less than the rating of the equipment containing overcurrent devices — or not less than the rating of the OCP device at the termination of the secondary conductors

240.21(C)(2) (4) Transformer Secondary Conductors

For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor.

This requirement applies to transformer secondary conductors that leave an enclosure or transformer vault.

E.g. 20A primary OC x 2:1 voltage ratio = 40A sec x 10: means the secondary conductors must be at least 1/10 of 400A, so the secondary ampacity is 40A or more.

240.21(C)(2) (2 & 3) 10 Ft Transformer Secondary Conductors

(2) The secondary conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.

(3) The secondary conductors are enclosed in a raceway, which shall extend from the transformer to the enclosure of an enclosed switchboard, panelboard, or control devices or to the back of an open switchboard.

240.21(C)(3) Industrial Not Over 25 Feet

For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor.

This requirement applies to transformer secondary conductors that leave an enclosure or transformer vault.

E.g. 20A primary OC x 2:1 voltage ratio = 40A sec x 10: means the secondary conductors must be at least 1/10 of 400A, so the secondary ampacity is 40A or more.
240.21(C)(3) Industrial Insulation Transformer Secondary Conductors Not Over 25 ft

3) For the supply of switchboards or switchgear in Industrial Installation
   For industrial installations only, where the length of the secondary conductors does not exceed 25 ft and complies with all of the following:

   (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
   (2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
   (3) All overcurrent devices are grouped.
   (4) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

240.21(C)(4) Outside Secondary Conductors

Where the conductors are located outdoors of a building or structure, except at the point of load termination, and comply with all of the following conditions:

(1) The conductors are protected from physical damage in an approved manner.
(2) The conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
(3) The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
(4) The disconnecting means for the conductors is installed at a readily accessible location complying with one of the following:
   a. Outside of a building or structure
   b. Inside, nearest the point of entrance of the conductors
   c. Where installed in accordance with 230.6, nearest the point of entrance of the conductors

240.21(C)(5) Secondary Conductors from a Feeder Tapped Transformer

Follow 240.21(B)(3) if the transformer is supplied by feeder taps

Taps supplying a transformer within 25 feet or less.
240.21(C)(6) Transformer Secondary Conductors

Secondary Conductors Not over 25 ft Long. Where the length of secondary conductor does not exceed 25 ft and complies with all of the following:

1. The secondary conductors shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the primary of the transformer.

   EG: 240:120 voltage ratio \times \frac{1}{3} the Pri OC 300A = 2 \times 100 = 200A sec ampacity

2. The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.15.

3. The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

240.21(D), (E), (F), (G)

(D) Service conductors: Follow 230.91
(E) Busway taps: Follow 368.17
(F) Motor circuit taps: Follow 430.28 and 430.53
(G) Conductors from generator terminals: Follow 445.12 and 445.13

240.21(G) Generator conductors

Overcurrent protection shall be permitted to be installed as close as practicable to the storage battery terminals in an unclassified location. Art 480 for storage batteries

Installation of the overcurrent protection within a hazardous (classified) location shall also be permitted.

240.21(H) Battery Conductors

No overcurrent device shall be connected in series with any conductor that is intentionally grounded, unless one of the following two conditions is met:

1. The overcurrent device opens all conductors of the circuit, including the grounded conductor, and is designed so that no pole can operate independently.

2. Where required by 430.36 or 430.37 for motor overload protection.

240.22 OCP in Grounded Conductor

No overcurrent device shall be connected in series with any conductor that is intentionally grounded, unless one of the following two conditions is met:

1. The overcurrent device opens all conductors of the circuit, including the grounded conductor, and is designed so that no pole can operate independently.

2. Where required by 430.36 or 430.37 for motor overload protection.
240.24(A) Location In, or On, Premises

Accessibility.
Switches containing fuses and circuit breakers shall be readily accessible and installed so the center of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 6 ft 7 in. above the floor unless one of the following applies:

1) For busways, as provided in 368.17(C).
2) For supplementary OCP as in 240.10
3) For overcurrent devices as described in 225.40 and 230.92.
4) For overcurrent devices adjacent to utilization equipment that they supply, access shall be permitted to be by portable means.

240.24(B) Occupancy

Each occupant shall have ready access to all overcurrent devices protecting the conductors supplying that occupancy, unless otherwise permitted in 240.24(B)(1) and (B)(2) below

1) Service and Feeder Overcurrent Devices. Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the service overcurrent devices and feeder overcurrent devices supplying more than one occupancy shall be permitted to be accessible only to authorized management personnel in the following:
   1) Multiple-occupancy buildings
   2) Guest rooms or guest suites

2) Branch-Circuit Overcurrent Devices
Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the branch-circuit overcurrent devices supplying any guest rooms or guest suites without permanent provisions for cooking shall be permitted to be accessible only to authorized management personnel.

240.24 Location

(C) Not Exposed to Physical Damage. Overcurrent devices shall be located where they will not be exposed to physical damage.

(D) Not In Vicinity of Easily Ignitible Material. Overcurrent devices shall not be located in the vicinity of easily ignitable material, such as in clothes closets.

(E) Not Located in Bathrooms. In dwelling units, dormitory units, and guest rooms or guest suites; overcurrent devices, other than supplementary overcurrent protection, shall not be located in bathrooms.

(F) Not Located over Steps. Overcurrent devices shall not be located over steps of a stairway.

240.24(F) Part III Enclosures
240.30 General

(A) Protection from physical damage
   (1) As when in cabinets or boxes
   (2) Mounting on open-type switchboards, panelboards, or control boards that are in rooms or enclosures free from dampness and easily ignitable material and are accessible only to qualified personnel

(B) Operating Handle
   The operating handle of a circuit breaker shall be permitted to be accessible without opening a door or cover.

240.33 Vertical Position

Enclosures for overcurrent devices shall be mounted in a vertical position. Circuit breaker enclosure are permitted to be installed horizontally when the circuit breaker is install as per 240.81 (Indicating ON or OFF)

Listed busway plus are allowed to be installed to meet the busway orientation.

240.40 Disconnecting Means for Fuses

Partial:
Cartridge fuses in circuits of any voltage where accessible to other than qualified persons, and all fuses in circuits over 150 volts to ground, shall be provided with a disconnecting means on their supply side so that each circuit containing fuses can be independently disconnected from the source of power.

240.41(A-B) Arcing or Suddenly Moving Parts

(A) Fuses and circuit breakers shall be located or shielded so that persons will not be burned or otherwise injured by their operation.

(B) Moving handles of ckt breakers must not cause injury when moved suddenly.
Where a change occurs in the size of the ungrounded conductor, a similar change shall be permitted to be made in the size of the grounded conductor.

Voltage drop may necessitate the need for increasing the size of the hot circuit conductors. This would also necessitate the need to increase the size of the grounded conductor.
240.50 General

(A) Maximum voltage for plug fuses for circuits not exceeding 125 volts between conductors and for circuits with a grounded neutral where the line to neutral voltage does not exceed 150V

(B) Each fuse shall be marked with the ampere rating

(C) Plug fuses 15A and lower will have a hexagonal window design

(D) When installed they have no energized parts exposed

(E) The screw shell of the plug fuse is connected to the LOAD side of the circuit

240.51 Edison-Base Fuses

(A) Classification. Plug fuses of the Edison-base type shall be classified at not over 125 volts and 30 amperes and below.

(B) Replacement Only. Plug fuses of the Edison-base type shall be used only for replacements in existing installations where there is no evidence of over fusing or tampering.

Plug Fuses

W Series Fast Acting
Ampere Ratings: 15A - 30Amps
Voltage Rating: 125V AC
Element is a simple fusible, metal link. For general purpose circuit protection. Quickly opens when short-circuit or overload occurs. Use for lighting and other non-motor circuits. Edison base.

SL and TL Series Time-Delay, Loaded Link
Ampere Ratings: 15 - 30Amps Voltage Rating: 125V AC

S and T Series Time-Delay, Dual-Element
Ampere Ratings: Type S 1/4A - 30Amps Type T: 1/10 - 30Amps Voltage Rating: 125V AC
240.52 Edison-Base Fuseholders

Fuseholders of the Edison-base type shall be installed only where they are made to accept Type S fuses by the use of adapters. (New installations)

240.53 Type S Fuses

Type S fuses shall be of the plug type and shall comply with 240.53(A)-(B):

(A) Classification.
Type S fuses shall be classified at not over 125 V and 0–15 amps, 16–20 amps, and 21–30 amps.

(B) Non-interchangeable.
Type S fuses of an ampere classification as specified in 240.53(A) shall not be interchangeable with a lower ampere classification. They shall be designed so that they cannot be used in any fuseholder other than a Type S fuseholder or a fuseholder with a Type S adapter inserted.

Type S Fuses – continued

(C) Non-removable
Type S adapters shall be designed so that once inserted in a fuseholder, they cannot be removed.

(D) Non-tamperable
Type S fuses, fuseholders, and adapters shall be designed so that tampering or shunting (bridging) would be difficult.

(E) Interchangeability
Dimensions of Type S fuses, fuseholders, and adapters shall be standardized to permit interchangeability regardless of the manufacturer.

240.60 General

(A) Maximum Voltage 300-Volt Type.
Cartridge fuses and holders of the 300 V type shall be permitted to be used in:

(1) Circuits not exceeding 300 V between conductors

(2) Single-phase line-to-neutral circuits supplied from a 3-phase, 4-wire, solidly grounded neutral source where the line-to-neutral voltage does not exceed 300 V
Eg: 120/208 for 300V fuses

(B) Non-interchangeable 0–6000-Ampere Cartridge Fuseholders.
Fuseholders shall be so that it will be difficult to put a fuse of any given class into a fuseholder that is designed for a current lower, or voltage higher, than that of the class to which the fuse belongs. Fuseholders for current-limiting fuses shall not permit insertion of fuses that are not current-limiting.

240.60(C) General

(C) Marking
Fuses shall be plainly marked, either by printing on the fuse barrel or by a label attached to the barrel showing:

(1) Ampere rating

(2) Voltage rating

(3) Interrupting rating where other than 10,000 amperes

(4) Current limiting where applicable

(5) The name or trademark of the manufacturer

The interrupting rating shall not be required to be marked on fuses used for supplementary protection.
240.60(D)

Renewable link fuses:
Class H fuses with renewable links, shall be permitted to be used for replacement only in existing installations where there is no evidence of over-fusing or tampering.

240.61 Classification

Cartridge fuses and fuseholders shall be classified according to voltage and amperage ranges.

- Fuses rated 1000 volts, nominal, or less shall be permitted to be used for voltages at or below their ratings.
- Higher voltage rated fuses can be used at lower utilization voltages, but not lower rated fuses at higher utilization voltages.

Class G Fuses – Various Voltages

Two fuses rated 300 V with Class G markings.

Fuse Bases for Bolt in Fuses (Blocks)

For bolt-in cartridge fuses, various base mountings are available.

TRON Clip-Clamps

Fuse Reducers for Class J Dimension Fuses
240.62 Reconditioned Equipment

Low-voltage (under 1000V) fuse holders, and non-renewable fuses, shall not be reconditioned.

Fuse Dimensions

250V fuses 1/10 0-30A ferrule end 2" long with ferrule 9/16" diameter
250V fuses 31-60A ferrule end 3" long with ferrule 13/16" diameter
600V fuses 1/0 = 10-30A ferrule are 5" long ferrule 13/16" diameter
600V fuses 31-60A are 5-1/2" long with ferrule 1-1/16" diameter

Fuses over 60 A – 600 A are knife blade ends

Classes of Fuses

The industry has developed basic physical specifications and electrical performance requirements for fuses with voltage ratings of 600 V or less. These are standards.

If a type of fuse meets the requirements of a standard, it can fall into that class.

Typical classes include:

- K
- RK1
- RK5
- G
- L
- H
- T
- CC
- J

Non-Current Limiting vs. Current Limiting

800A Fuse
Class CC Rejection-Type Fuses

XXX-R is rejection fuses. Type CC are current limiting fuses – R is a rejection fuse meaning the fuse holder will not accept or “reject” any non-current limiting CC fuse.

**Quick Acting, Class J Fuses**

Quick Acting
Ampere Ratings: 1-600 Amps.
Voltage Rating: 600 V AC (or less)

Current Limiting
Interrupting Rating: 200,000A RMS Sym.

**Dual Element -- Time Delay Fuses**

FRS-R
600V Knife blade

FRN-R 250V ferrule end

**Rejection Fuseholders**

**Time-Delay Class G Fuses**

SC
Fast Acting (1/2-6A), Class G
Time-Delay (7-60A), Class G
Construction: Melamine Tube
Ampere Ratings: ¾ - 60A
Voltage Rating: ¾ - 60A: 600V AC/170V DC or less
25-60A: 480V AC/300V DC or less
Interrupting Rating: 100,000A RMS Sym., 10,000A DC
**2020 NEC® Overcurrent Protection (2-hr) – Part 2**

### 240.67 Arc Energy Reduction

**Effective on Jan. 1, 2020, where fuses are 1200 A or more - follow (A) and (B) below:**

(A) Documentation needs to be available as to the methods used to reduce clearing time. The documentation shall be available to all who are concerned.

(B) Either the fuse must clear the overcurrent in 0.07 seconds or other one of the methods as referenced in 240.6.7B(1-4) (below) shall be used.

1. Differential relaying
2. Energy reduction maintenance switching
3. Active arc mitigation system
4. Current limiting electronic fuses
5. An approved equivalent means

### E-Rated Medium Volt for Potential & Small Power Transformers

- **JCD, JCW, JCE, JCQ, JCI & JCT**
- **Current Limiting**
- **Indicating/Non-Indicating**
- **Plated Ferrules**

**Voltage Rating:**
- Max. Design: 2475, 2750, 5500, 8300, 15,500
- Current Ratings: 1/4E through 10E

### One-Time General Purpose Fuses - NON and NOS

- **General Purpose Application**
- **Non-Current Limiting**
- Ampere Ratings: 1/8-600 Amps
- **Voltage Rating:**
  - NON: 250 Volts AC, 125 Volts DC (0-100A)
  - NOS: 600 Volts AC
- **Interrupting Rating:**
  - 50,000A RMS Sym. (1-60A)
  - 10,000A RMS Sym. (65-600A)
  - 10,000A @ 125V DC (NON 0-100A)

### Dual Element Time Delay Fuses

- **SHORT-CIRCUIT ELEMENTS**
- **OVERLOAD ELEMENT**

### Dual-Element, Time-Delay Fuses

- **Overload**
- **Or short ckt**

---

**Arc Energy Reduction**

*By injecting a predetermined current into the circuit breaker, it is possible to determine whether the relay will trip at this current and, if so, how long the current needs to flow before the trip is initiated.*
Part VII

CIRCUIT BREAKERS

240.80 Method of Operation

• Circuit breakers shall be trip free and capable of being closed and opened by manual operation.

• Normal method of operation by other than manual means, such as electrical or pneumatic, shall be permitted if means for manual operation are also provided.

240.81 Indicating

• Circuit breakers shall clearly indicate whether they are in the open “off” or closed “on” position.

• Where circuit breaker handles are operated vertically rather than rotationally or horizontally, the UP position of the handle shall be the ON position.

240.83 Marking

(A) Durable and Visible. Circuit breakers shall be marked with the ampere rating that will be visible after installation. Such marking shall be permitted to be made visible by removal of a trim or cover.

(B) Location. Circuit breakers rated 100 amperes or less and 1000 volts or less shall have the ampere rating molded, stamped, etched, into their handles or escutcheon areas.

(C) Interrupting Rating. Every circuit breaker having an interrupting rating other than 5000 amperes shall have its interrupting rating shown on the circuit breaker.

(D) and (E) continued on next slides.
240.83 Marking

(D) Used as Switches
- CB used as switches in 120 V and 277 V fluorescent lighting circuits shall be listed and shall be marked SWD or HID.
- Circuit breakers used as switches in high-intensity discharge lighting circuits shall be listed and shall be marked as HID.

(E) Voltage Marking
Circuit breakers shall be marked with a voltage rating not less than the nominal system voltage that is indicative of their capability to interrupt fault currents between phases or phase to ground.

GFCI 1-Pole and 2-Pole

GFCI 2-Pole 120/240V with Shared Neutral

GFCI 2-Pole / 240V – Without Neutral

A Look Inside an AFC Breaker

Figure 3: In two pole GFCI circuit breakers, single phase 120 V loads are not to be served, both of neutral conductor and the neutral conductors must be grouped into a single circuit. The neutral conductor must be connected to the neutral bus bar.
2020 NEC® Overcurrent Protection (2-hr) – Part 2

CH 2-Pole AFCI

**Combination 2 Pole Arc Fault Configurations**

- 3 Pole Shared Neutral with Multi-Duplex Receptacle Application
- 2 Pole Switch Load Application Sourced by 120/240 Vac
- 3 Pole Shared Neutral with Duplex Receptacle Application

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240.86 Series Ratings

Where a circuit breaker is used on a circuit having an available fault current higher than the marked interrupting rating by being connected on the load side of an acceptable overcurrent protective device having a higher rating, the circuit breaker shall meet the requirements specified in (A) or (B), and (C).

---

240.86 Series Ratings

(A) Selected Under Engineering Supervision in Existing Installations.

The series rated combination devices shall be selected by a licensed professional engineer engaged in the design or maintenance of electrical installations. The selection shall be documented and stamped by the professional engineer. This series combination rating, including identification of the upstream device, shall be field marked on the end use equipment.

For calculated applications, the engineer shall ensure that the downstream circuit breaker(s) that are part of the series combination remain passive during the interruption period of the line side fully rated, current-limiting device.
240.86 Series Ratings

(B) Tested combinations
The combination of line side OCP and load side ckt breakers is to be tested and marked on the equipment.
(Must be available to any qualified uses of the OCP)

(C) Motor contribution: Series rated equipment shall not be used ...
(1) Where motors are connected between the up stream and down stream rated combination.
(2) Where the sum of the motor full load currents exceeds 1% of the IR rating of the lower rated circuit breaker

240.87 Arc Energy Reduction
Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200 A or higher, 240.87(A) and (B) shall apply. (below)

(A) Documentation. Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s), and what method of calculation was used.

(B) Method to Reduce Clearing Time. One of the following shall be set to operate at less than the available arcing current:
(1) Zone-selective interlocking
(2) Differential relaying
(3) Energy-reducing maintenance switching with local status indicator
(4) Energy-reducing active arc flash
(5) An instantaneous trip setting at less than fault current. No temporary overrides are permitted
(6) An instantaneous override that is less than fault current
(7) An approved equivalent means

240.88 Reconditioned Equipment
Reconditioned equipment shall be listed as re-conditioned and marked as such.
The original listing must be removed and new listing applied.

(A) Circuit breakers (See P. 107 in 2020 NEC)

(B) Components (see P. 107 in 2020 NEC)

240.90 General
Overcurrent protection in areas of supervised industrial installations shall comply with all of the other applicable provisions of this article, except as provided in Part VIII.

The provisions of Part VIII shall be permitted only to apply to those portions of the electrical system in the supervised industrial installation used exclusively for manufacturing or process control activities.
240.91 Protection of Conductors

Conductors shall be protected in accordance with 240.91(A) or (B). Below
(A) General. Conductors shall be protected in accordance with 240.4.
(B) Devices Rated Over 800 Amperes. Where the overcurrent device is rated
over 800 amperes, the ampacity of the conductors it protects shall be equal to
or greater than 95 percent of the rating of the overcurrent device specified in
240.6 in accordance with (B)(1) and (2).

(1) The conductors are protected within recognized time vs. current limits
for short-circuit currents
(2) All equipment in which the conductors terminate is listed and marked
for the application

240.92 Location in Circuit

An OCP shall be install in each ungrounded conductor as per (A)(E):

(A) Feeder and branch circuits are protected at their origin as allowed in
240.21
(B) Feeder taps may follow 240.21 (B) (2) – (4)
(C) Transformer secondary taps for separately derived systems follow
240.21 (C) (1)–(3) See this section in NEC.
(D) Outside feeder taps See this section in NEC.
(E) Protection by primary OCP for transformers

240.100 Feeders and Branch Circuits

(A) Location and Type of Protection.
Feeder and branch circuit conductors shall have overcurrent protection in
each ungrounded conductor located at the point where the conductor
receives its supply, or at an alternative location in the circuit when designed
under engineering supervision that includes, but is not limited to,
considering the appropriate fault studies and time–current coordination
analysis of the protective devices, and the conductor damage curves.
The overcurrent protection shall be permitted to be provided by either
240.100(A)(1) or (A)(2). (following)

240.100(A)(1) & (2)

(1) Overcurrent Relays and Current Transformers. Circuit breakers used for overcurrent
protection of 3-ph circuits shall have a minimum of 3 overcurrent relay elements operated
from three current transformers. The separate overcurrent relay elements (or protective
functions) shall be permitted to be part of a single electronic protective relay unit.
On 3-phase, 3-wire circuits, an overcurrent relay element in the residual circuit of the
current transformers shall be permitted to replace one of the phase relay elements. An
overcurrent relay element, operated from a current transformer that links all phases of a 3-
ph, 3-wire circuit, shall be permitted to replace the residual relay element and one of the
phase-conductor current transformers. Where the neutral conductor is not re-grounded on
the load side of the circuit as permitted in 250.184(B), the current transformer shall be
permitted to link all 3-ph conductors and the grounded circuit conductor (neutral).
(2) Fuses. A fuse shall be connected in series with each ungrounded conductor.

Part IX
OVERCURRENT PROTECTION OVER 1000V, NOMINAL

Cable Limiters

Interrupting Rating:
200,000 Amps.,
600 Volts AC

RMS Symmetrical

UL Listing:
KDM, KDR, KDP
and KFM

2020 NEC® Overcurrent Protection (2-hr) – Part 2
240.100 (B) & (C) Branch Circuits and Feeders

(B) Protective Devices.
The protective device(s) shall be capable of detecting and interrupting all values of current that can occur at their location in excess of their trip-setting or melting point.

(C) Conductor Protection.
The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damage or dangerous temperatures in conductors or conductor insulation under short circuit conditions.

Medium-Voltage Fuse Links

Dummy Fuse “Neutrals”
These are not fuses, Listed Product

Fault Current Calculations

Procedure
To determine the fault current at any point in the system, first draw a one line diagram showing all of the sources, as well as the impedances of the circuit components. To begin, all system components including the utility should be shown.

Web-Based Calculator

Eaton.com/Bussmannseries/FC2

2020 NEC® Overcurrent Protection (2-hr) – Part 2
One-Line Diagram

Sample from FC²

50,914A Fault at Transformer Sec.

Fault occurs 150 ft from secondary = 41,011 A
SCCR greater than 41,011 A
Can create a label sent to user.

Manual Procedure = Ugly’s

It must be understood that the short circuit calculations are done without considering current limiting devices in the system.

Short circuit at the transformer secondary terminals:

\[ I_{sc} = \frac{\text{Rated transformer current} - \text{full load at secondary}}{\% \text{ impedance (decimal)}} \]
1-Phase Fault Current Calculation

1. It is necessary that the proper impedance be used to represent the primary system. For 3Ø fault calculations, a single primary conductor impedance is only considered from the source to the transformer connection. This is compensated for in the 3Ø short-circuit formula by multiplying the single conductor or single-phase impedance by 1.73.
   However, for single-phase faults, a primary conductor impedance is considered from the source to the transformer and back to the source. This is compensated in the calculations by multiplying the 3Ø primary source impedance by two.

2. The impedance of the center-tapped transformer must be adjusted for the half-winding (generally line-to-neutral) fault condition.
   The diagram at the right illustrates that during line-to-neutral faults, the full primary winding is involved, but only the half-winding on the secondary is involved. Therefore, the actual transformer reactance and resistance of the half-winding condition is different than the actual transformer reactance and resistance of the full winding condition. Thus, adjustment to the %X and %R must be made when considering line-to-neutral faults. The adjustment multipliers generally used for this condition are as follows:
   1.5 times full winding %X on full winding basis.
   1.2 times full winding %X on full winding basis.
   Note: %X and %R multipliers given in “Impedance Data for Single Phase Transformers” Table may be used, however, calculations must be adjusted to indicate transformer kVA input.

3. The impedance of the cable and two-pole switches on the system must be considered “both-ways” since the current flows to the fault and then returns to the source. For instance, if a line-to-line fault occurs 50 feet from a transformer, then 100 feet of cable impedance must be included in the calculation.
   The calculations on the following pages illustrate 1Ø fault calculations on a single-phase transformer system. Both line-to-line and line-to-neutral faults are considered.

Fault X:
- Step 1: \( I_L = \frac{75.5 \times 1000}{240} = 312.5 \) A
- Step 2: Multiplier = \( \frac{200}{12} = 16.7 \)
- Step 3: \( Z_L = \frac{312.5 \times 71.43}{27,322} \)
- Step 4: \( I = 2 \times 312.5 \times 22,322 = 2080 \)
- Step 5: \( M = t \times 3.058 = 3.058 \)
- Step 6: \( Z_L \times L = 22,322 \times .8957 = 19,493 \) A
Transformer Short Circuit Amps

Various Types of Short Circuit Currents as a Percent of Three Phase Bolted Faults (Typical).

<table>
<thead>
<tr>
<th>Type of Fault</th>
<th>Current as Percent of Full Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Phase Bolted Fault</td>
<td>100%</td>
</tr>
<tr>
<td>Line-to-Line Bolted Fault</td>
<td>87%</td>
</tr>
<tr>
<td>Line-to-Ground Bolted Fault</td>
<td>100%</td>
</tr>
<tr>
<td>Line-to-Line Arcing Fault</td>
<td>91% (480V)</td>
</tr>
<tr>
<td>Line-to-Ground Arcing Fault</td>
<td>74% (480V)</td>
</tr>
</tbody>
</table>

*Typically much lower but can actually exceed the Three Phase Bolted Fault if it is near the transformer terminals.

Impedance Data for Single-Phase and Three-Phase Transformers (Supplement)

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>Transformer Nameplate Impedance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1.3</td>
</tr>
<tr>
<td>35</td>
<td>1.1</td>
</tr>
<tr>
<td>50</td>
<td>1.1</td>
</tr>
<tr>
<td>75</td>
<td>1.6</td>
</tr>
<tr>
<td>100</td>
<td>1.5</td>
</tr>
<tr>
<td>150</td>
<td>1.1</td>
</tr>
<tr>
<td>225</td>
<td>1.1</td>
</tr>
<tr>
<td>300</td>
<td>1.1</td>
</tr>
<tr>
<td>400</td>
<td>1.3</td>
</tr>
<tr>
<td>600</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*These represent actual transformer nameplate ratings taken from field installations.

Note: U.L. Listed transformers 25 kVA and greater have a ±10% tolerance on their impedance nameplate.
2020 NEC Overcurrent Protection
Part 2

Thank You for Attending!
Extra Voltage Drop Material on the following slides.

QUESTIONS?

Voltage Drop Extra Material

Voltage Drop
Single-Phase

\[ VD = 2 \times K \times I \times L \]
\[ \text{CM} \]

- \( VD \) = Voltage drop
- \( K \) = Ohms per mil foot – copper @75˚C is 12.8
- \( I \) = Current in amperes
- \( L \) = Length of wire one direction
- \( \text{CM} \) = Circular mil area of conductor

Voltage Drop
Three-Phase

\[ VD = 1.732 \times K \times I \times L \]
\[ \text{CM} \]

Voltage Drop Problem

What size copper conductor is needed to keep voltage drop to 3% or less for a 120V, single-phase circuit that is serving a load of 8 amps and is 140’ in length in one direction? Use \( K = 12.8 \)

1. \( 3\% = 0.03 \times 120V = 3.6V \)
Voltage Drop Problem

What size copper conductor is needed to keep voltage drop to 3% or less for a 120V, single-phase circuit that is serving a load of 8 amps and is 140’ in length in one direction? Use K = 12.8

1. 3% = 0.03 \times 120V = 3.6V
2. 3.6VD = \frac{2 \times 12.8 \times 8 \times 140}{\text{CM}}
3. CM = \frac{2 \times 12.8 \times 8 \times 140}{3.6} = 7965

Answer: 10 AWG

End of Voltage Drop Problems

QUESTIONS?

Thank You for Attending!